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Short Note

Selection of Appropriate Sewage Treatment Technology for Kancheepuram City

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Abstract: Various types of sewage treatment technologies are available for the treatment and reuse of sewage in India. It is difficult to select an appropriate treatment technology for the specific region such as rural, urban or metropolitan area. Suitability to techno economic analysis, life cycle, cost analysis, and benefit cost ratio can be used as financial management tool to take final decision. This paper highlights the application of techno-economic analysis for the selection of appropriate technology of sewage treatment for Kancheepuram town of Tamil Nadu. Out of five different types of sewage treatment technologies that are being used in India, the waste stabilization pond has been found to be the most economical option to treat sewage as the cost of land in Kancheepuram city is less than Rs. 6.5 million per ha (i.e., Rs. 650/sqm). Between Rs. 6.5 and Rs. 13.0 million per ha, the Upflow Anaerobic Sludge Blanket (UASB) with Final Polishing Pond (FPP) is economical. Above Rs. 13.0 million per ha, the Moving Bed Biological Reactor (MBBR), Sequencing Batch Reactor (SBR) and Activated Sludge Process are found to be economical. The selection of technology has been done by calculating the benefit cost ratio, assuming a discount rate of 10%.

Key words: Benefit-cost ratio, life cycle cost analysis, sewage treatment plant, techno economic analysis, waste stabilization pond.

Introduction

Kancheepuram (12°50' N and 79°42' E) is an ancient historic temple city situated on the northern banks of river Vegavathi, a tributary of Palar River in Tamil Nadu, India. It is one of the important historical and sacred cities in India. It is famous for historic temples such as Kanchi Kamaatchi Amman, Kailasanathar and Kanchi Sankarachariyar Mutt besides handloom silk sarees. The city is generating presently around 12 MLD.

In 1972, the Government of India declared Kancheepuram as one of the hyper-endemic towns in the country and approved a sewerage scheme which was executed and commissioned in 1975 at a cost of Rs. 12 million by Tamil Nadu Water Supply & Drainage Board (TWAD Board). The sewage scheme was designed for a population of 1,50,000 with water supply at the rate of 135 lpcd and the average flow of 9 MLD.

In the existing sewerage system, there are two zones viz East zone and West zone. The coverage of collection system network is 73.3 km (66% coverage) of the total road length of 110.91 km. There are 23,426 sewerage connections in the city. The sewage is collected in the two zones by gravity to the collection sumps in pumping stations in the respective zone. The sewage is then pumped to the 9 MLD waste stabilization ponds located at Thirukalimedu at a distance of about 3 km from the town. The treated effluent is used for grass farming and growing of coconut trees. Due to the increase in population, the sewage generation has increased to more than 12 MLD.

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Due to the inadequate capacity of the existing sewerage system, the overflow sewage is discharged into the Manjal Neer stormwater drain, which finally reaches the Vaegavathi River causing water pollution. The modern rice mills and the dying units are also discharging their effluent into the Manjal Neer channel without any treatment. In addition, the inlet chambers in STP are damaged and leaking. Silt deposited in the ponds was not removed and the capacity of the pond has thus reduced. Poor sewage treatment and disposal affects the health of the local population as evident by the fact that the children were affected by helminthes, coliform, enteric and diarrhoeal diseases, the most common cause of infant mortality.

In view of the problems on environmental, social, economical, and agricultural levels, there has been felt an urgent need to tackle the problem by providing sewage/wastewater treatment technologies appropriate to the given area.

Technologies for Wastewater/Sewage Treatment

A number of treatment systems can be applied for sewage treatment in India and elsewhere (AHEC, 2006; Arceivala and Asolekar, 2007; Chagnon, 2002; Friedler and Pisanty, 2006; Green et al., 1995; Hernandez and Sala, 2006; Metcalf and Eddy, 2007; NRCD, 1997; NRCD, 2002; Qasim, 1999; Shahalam, 1982). Most of the treatment systems are biological and have their own merits and demerits. To select the most feasible sewage treatment option, the following criteria can be adopted for the selection of the sewage treatment options:

- Low power requirements.
- Suitable removal efficiencies to meet effluent discharge standards.
- The option should be simple to construct, easy to operate and have low operation and maintenance cost over a longer period of time.

Table 1: Comparison of different features of treatment technologies

S. No	*Features*	*Waste water/Sewage treatment technologies*				
		WSP	*UASB+FPP*	*ASP*	*MBBR*	*SBR*
1.	Type of process	Aerobic suspended growth process	Anaerobic suspended growth process	Aerobic suspended growth process	Aerobic fixed film growth process	Aerobic suspended growth process
2.	Cost for installation	Less, easy construction	Medium	Higher than USAB	Slightly higher than ASP	High
3.	Operation and Maintenance	Less, easy to maintain	Slightly higher than WSP Requires skilled personnel	High, requires technical and skilled personnel	Slightly lower than ASP but higher than UASB. Requires skilled personnel	Very high. High technical and skilled personnel required
4.	Area required	Large area required	Moderately large area required	Medium area	Very small area required	Small area
5.	Power requirement	No power	Almost negligible power	Large power required	Less than ASP but higher than UASB	Less power than ASP
6.	Effluent Coliforms (MPN/100 mL)	10^4-10^5	10^4-10^5	10^4-10^5	10^3-10^4	10^3-10^4
7.	Effluent quality	Meets the standard	Meets the standard	Very good quality	Meets the standard	Best quality
8.	Sludge production	Less	Medium	More	Medium	Medium
9.	Expandability	Possibility providing aerators	Limited	Limited	Possibility of extra media filling	Easy
10.	Sensitivity of process	Less sensitive	Highly sensitive	Moderately sensitive	Less sensitive	Less sensitive

MLSS – Mixed Liquor Suspended Solids, SVI – Sludge Volume Index, F/M Ratio – Food to Microorganism Ratio, PLC – Programmable Logic Controller

- The treated effluent should be reused effectively for irrigation, industrial and other non-potable purposes.

The following treatment options have been selected for techno economic evaluation:

1. Activated Sludge Process (ASP)
2. Upflow Anaerobic Sludge Blanket (UASB) with Post Treatment (Final Polishing Pond)
3. Moving Bed Biological Reactor (MBBR)
4. Waste Stabilization Pond (WSP)
5. Sequencing Batch Reactor (SBR)

The technical comparison of these options is given in Table 1.

Selection of Treatment Technologies

The parameters used in the selection of sewage treatment technologies are capital cost, land and power requirements (Li Xian-wen, 1995; Srinivasan et al., 1995; Tassou, 1988; Tsagarakis et al., 2003). Other factors include constituents to be treated, limitation of effluent standard, and proximity to build-up area, hydraulic requirements, sludge disposal, energy requirements and plant economics (Qasim, 1999). The selection of suitable method for sewage treatment for a given situation depends on the following factors: (i) volume of daily flow to be treated; (ii) area of land required for the installation of the plant; (iii) the method of supply of oxygen to the microorganisms; (iv) mechanical equipment involved; (v) ease of operation and maintenance; (vi) capital cost of the plant; (viii) annual operation and maintenance cost etc.

Material and Methods

Field survey was conducted for the primary and secondary data collection. The secondary data on population, water supply, and sewage generation was collected from the district office. Grab samples of sewage and industrial effluent were collected and analyzed in the State pollution control laboratory and the results are reported in Table 2.

Table 2: Analysis of sewage and industrial effluents

S. No.	*Parameters*	*Sewage samples*	*Industrial effluents*	
			Rice mill	*Dyeing units*
1.	BOD (mg/L)	180	72	80
2.	COD (mg/L)	482	188	248
3.	Suspended solids (mg/L)	98	46	63

The results indicate that the BOD of sewage is 180 as against 250 required by STPs, whereas the effluents from rice mill and drying industries are not suitable for treatment by STP but by effluent treatment plant employing chemical method.

The field visit to various types of sewage treatment plant operating in India was conducted and data related to construction and operation cost were collected. Moreover, technical problems in various STPs was also recorded. Techno-economic analysis of various sewage treatment technologies was carried out.

Cost/Benefit Analysis

The costs of construction for WSP, UASB and ASP were calculated as per the schedule of rates of Tamil Nadu and as per MLD cost used in the study. The cost also coincides with the cost used for comparison of technology in the DPR for Bhubaneshwar (AHEC, 2006; Arceivala and Asolekar, 2007; Chagnon, 2002; Friedler and Pisanty, 2006; Green et al., 1995; Hernandez and Sala, 2006; Li Xian-wen, 1995; Mara, 1997; Merz, 2000). The cost of construction per MLD for the MBBR was provided by Thermax, Pune. The construction cost per MLD for SBR Plant was assessed from C-Tech, Mumbai. The annual operation and maintenance cost was calculated on the basis of energy, personnel, chemicals and maintenance requirements.

The life cycle cost analysis of various options is highly dependent on the capital cost, cost of land and annual maintenance cost (Srinivasan et al, 1995; Tassou, 1988; Tsagarakis et al., 2003). Though the land to the tune of 112 acres is available with the municipality and the cost of the land has been taken into account to compare the technologies. The cost of land has been taken as Rs. 1.50 lac per ha. The cost benefit analysis with land cost of Rs. 1.50 lacs per ha is given in Table 3.

Results and Discussion

Based on lowest life cycle (Rs. 80.2 million) and highest benefit-cost ratio (1.02) assuming all the options considered (Table 3), WSP has been as the cost effective option for sewage treatment for Kancheepuram city. The benefit-cost ratio was computed assuming 10% discount rate and life of 20 years. The 50% of cost of expenditure has been considered assuming that 50% grant will be provided by NRCD (Mara, 1998; Merz, 2000; Metcalf and Eddy, 2003).

The life cycle cost analysis has also been done for various land costs for 15.05 MLD and the results are explained in Figure 1, which indicates that WSP is the

Table 3: Life cycle cost analysis

S. No.	*Parameters*	*Unit*	*Treatment technologies*				
			WSP	*UASB +FPP*	*MBBR*	*ASP*	*SBR*
1.	Measured flow in 2007	MLD	12.11	12.11	12.11	12.11	12.11
2.	Design flow in 2017	MLD	15.05	15.05	15.05	15.05	15.05
3.	Unit area of STP required	ha	0.917	0.225	0.021	0.102	0.032
4.	Area required for design flow	ha	13.80	3.39	0.32	1.54	0.48
5.	Rate of land	Rs. Million/ha	0.15	0.15	0.15	0.15	0.15
6.	Unit cost of construction of STP	Rs. Millions/MLD	1.7	4.0	5.0	4.5	5.5
7.	Unit cost of annual O&M of STP	Rs. Millions/MLD	4.11	6.62	8.52	8.61	7.88
8.	Cost of land	Rs. Millions	20.70	5.08	0.48	2.30	0.72
9.	Cost of construction of STP (excluding cost of land)	Rs. in Millions	25.5	60.2	75.2	67.7	82.7
10.	Cost of construction of STP (including cost of land)	Rs. in Millions	27.6	60.7	75.0	67.5	82.8
11.	Total cost of annual O&M of STP	Rs. in Millions	6.1	9.9	12.8	12.9	11.8
12.	Capitalized cost of O&M for 20 years @ 10% int.	Rs. in Millions	52.6	84.8	109.2	110.2	100.9
13.	Life cycle cost of STP for 20 years	Rs. in Millions	80.2	145.5	184.5	178.2	183.8

Note:

(i) Capital cost of WSP, UASB and ASP (Chagnon, 2002; Friedler and Pisanty, 2006) while for SBR, the per MLD rates were taken from Thermax and C-Tech respectively.

(ii) The rate for land obtained from the Registrar Office, Kancheepuram.

(iii) The annual maintenance cost is based on the requirements of machineries for each technology.

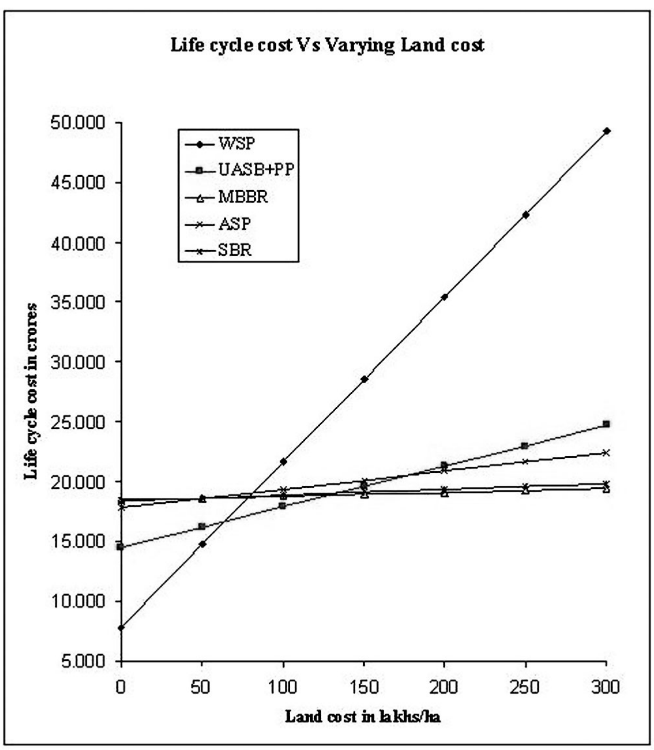

Figure 1: Life cycle cost (15 MLD) Vs Land cost

cost effective technology upto a land cost of Rs. 6.5 million per ha. The upflow anaerobic sludge blanket (UASB) with final polishing pond is economical between Rs. 6.5 and 13.0 million/ha land. Above Rs. 13.0 million per ha, sequencing batch reactor (SBR), moving bed biological reactor (MBBR), and activated sludge process are found economical. For Kancheepuram, WSP has been found as the better and economical sewage treatment technology and can meet the national standards if maintained properly. The methane can be recovered by providing fermentation pits and gas collected through gas liquid-solids separators.

Conclusions

Techno-economic analysis is the pre-requisite for the selection of appropriate technologies. Escalating land prices and land acquisition for STP is becoming a troublesome task nowadays, sometimes, due to the objections for the construction of WSP from the nearby dwellers, fear of foul smell, and mosquito nuisance. As per the life cycle cost and benefit cost analysis of various types of sewage treatment technologies, WSP has been the best option of sewage treatment for Kancheepuram city. The outcome is further authenticated by calculating the life cycle cost vs land cost which indicates that WSP is the appropriate sewage treatment technology upto Rs. 6.5 million/ha for the city.

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